Landslide Hazard and Risk in the Campi Flegrei Caldera, Italy

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Abstract

This chapter deals with the main characteristics of the mass movements affecting the slopes of the Campi Flegrei Volcanic Field. To this aim, giving due credit to previous works, an overview of the Phlegraean landslides is presented, taking into account other ongoing researches. The prevailing landslide types depend upon the lithological characteristics of the rocks involved: slides and flows dominate in the loose pyroclastic deposits, while falls and topples characterise the slopes where tuffs and lavas crop out. All the Phlegraean landslides show a moderate mobility, with a maximum runout distance lower than 350 m, and a mean angle of reach equal to 39°. More than 15% of the whole territory of the six Phlegraean towns is prone to landslide hazard, though the distribution of at-risk areas among the six towns is uneven (e.g., Monte di Procida, 31.7%; Quarto, 5%). Due to the intense urbanisation of the area, such a hazard results in a quite high risk. In recent years, a number of structural countermeasures, including low-impact soil bioengineering techniques, have been introduced as to mitigate the landslide risk in the Neapolitan-Phlegraean area. However, a paradigm shift is strongly needed, due in part to the persistent economic crisis, which should induce to emphasise the importance of non-structural preventive solutions, among which the improvement of the urban communities' societal resilience is of paramount importance.

1 Introduction

The main concern in a densely populated active volcanic area, such as the Campi Flegrei volcanic field (CFvf), is obviously and correctly addressed to the societal impacts deriving from a future eruption or volcanic-related events. However, volcanic eruptions, earthquakes and bradyseismic activity have continuously combined to create a unique geomorphologic scenario, characterised by a volcanic-derived hilly landscape, mostly carved into loose or variably consolidated pyroclastic deposits. For a reconstruction of the geological and volcanological evolution of the CFvf, including the Campi Flegrei caldera (CFc), as well as of the characteristics of the outcropping rocks, see Chap. Volcanic and Deformation History of the Campi Flegrei Volcanic Field, Italy. The petrophysical characteristics of most widespread rock-types of this volcanic field and their use are presented in Chap. Building Stones and

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Technological Materials of the Campi Flegrei Caldera, Italy. Such terrains, generally displaying poor geomechanical properties, are exposed to both natural and anthropogenic factors that together predispose and sometimes trigger slope instabilities.

The occurrence of both endogenous and exogenous factors controlling the everyday morphodynamics of the Phlegraean hills, makes them particularly vulnerable to mass movements, which only in the last decades have received the proper attention they deserve from the scientific community and public administrators.

In the following, data from the literature and from ongoing studies on the landslides affecting the CFvf, hereinafter called "Phlegraean landslides", will be described. Then the overall hazard and risk conditions will be critically commented on, with reference to the official documents recently produced by the competent authorities. Finally, some considerations will be given to the possible scenarios related to the landslide risk mitigation and management in the Neapolitan-Phlegraean area.

2 Previous Studies

Although landslides have been a serious geohazard in the CFvf since distant historical times, they have been a focus of a systematic scientific research only in the last few decades. In fact, Naples and the other Phlegraean towns of Pozzuoli, Bacoli, Monte di Procida, Quarto and Marano di Napoli (Fig. 1) were not cited in the first nation-wide report on landslides compiled in Italy by the geographer Roberto Almagià at the beginning of the twentieth century (Almagià 1907, 1910), through a questionnaire sent to local governing bodies, eventually integrated with field-checks.

Dell'Erba (1923) was probably the first author to highlight the importance of landslides in the Neapolitan-Phlegraean area. He described some landslides which involved the Neapolitan Yellow Tuff (NYT; ~15 ka; see Chap. Volcanic and Deformation History of the Campi Flegrei Volcanic Field, Italy) between 1886 and 1911, pointing out the close relationship existing between mass movements and quarrying activity. The following decades were again characterised by a notable absence of the CFvf from both technical and scientific documents. Such an absence is well testified by the volume published by the Italian Ministry for the Public Works (Ministero per i Lavori Pubblici) (1965), where, in a synopsis of the inventories performed in 1957 and 1963 through the local ministerial divisions, no landslide is mentioned for the Phlegraean towns.

A paper by Beneduce et al. (1988) can be considered as the first modern contribution aimed at a deeper comprehension of causes and features of the Phlegraean landslides. It reports the main results of a research carried out after a rainfall-induced event occurred on February 1986. Catenacci (1992), in a catalogue of the main hydraulic and geological disasters occurred in Italy from 1945 to 1990, pointed out three landslides at Naples. Pellegrino (1994) reviewed the landslides studied by Beneduce et al. (1988), in the framework of a wider study dealing with the landslides in the Neapolitan area. Some rainfall-induced landslides occurred at Naples in 1910, are mentioned by Migale and Milone (1998) in a historical research on debris flows in the Campanian pyroclastic deposits.

A specific archival research on the historical mass movements at Naples and the CFvf has been conducted by Calcaterra and co-workers and is still underway; the results so far obtained have been published in a number of papers (Calcaterra et al. 2002, 2003b; Calcaterra and de Luca Tupputi Schinosa 2006; Morra et al. 2010; Di Martire et al. 2012). The same research group has analysed a cluster of shallow landslides triggered by a rainfall event that occurred in Naples on January 1997 (Calcaterra and Guarino 1999a, b). The relationship between mass movements and rainfall at Naples has also been dealt with by Esposito et al. (2002).

The Camaldoli Hill, representing the main peak within the entire CFvf (Fig. 1), was treated in detail by Parise et al. (2004) and by Calcaterra et al. (2007a). The latter paper was centred on the flow-like movements in the post-NYT loose

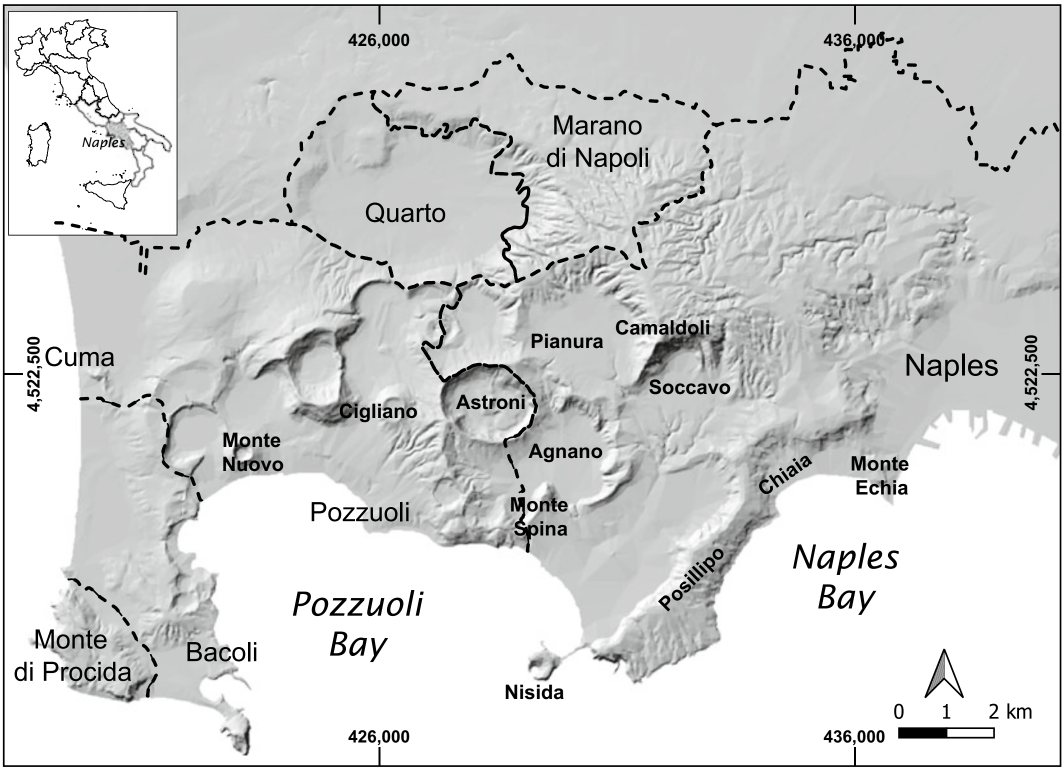

Fig. 1 Naples and the five Phlegraean towns within the Campania region (highlighted in the inset) that are the site of the landslides discussed in this chapter

pyroclastic terrains, while in the first contribution rockfall instabilities were analysed. The same hill has been the study area chosen by Calcaterra et al. (2007b) to highlight the role played by changes in land use and by wildfires as factors predisposing to landslides and erosion. The flow-like movements affecting the youngest pyroclastic deposits of the Phlegraean sequence have been further studied with the help of some physically-based models, aiming to assess the proneness of the Neapolitan slopes to the detachment events ranging from slides to flows (Calcaterra et al. 2004a, 2005, 2010; Calcaterra 2010). Taking advantage of the ongoing research on several areas in the Campania region, a number of papers have been published. In these papers the features of the Phlegraean landslides in pyroclastic loose terrains have been critically compared to similar phenomena that involve the pyroclastic cover, mainly of Vesuvian origin, mantling the carbonate ridges bordering the Campanian Plain (de Riso et al. 1999, 2004, 2007; Calcaterra et al. 2003b, 2004b; Palma et al. 2009; Calcaterra 2010).

The published data have been fruitfully used by the Basin Authority of the North-western Campania Region, a governmental agency in charge of land planning and management, to issue the Hydro-geomorphological Setting Plan in 2002 and to revise it in 2010 (Basin Authority of North-western Campania Region 2002, 2010). Such agency has been recently incorporated into a wider administrative body (*Autorità di Bacino Distrettuale dell'Appennino Meridionale*, www.distrettoappenninomeridionale.it), responsible for the whole southern Italy. The Plan is an act aimed at identifying landslide and flood risk, through a set of basic thematic maps, among which the Landslide-Inventory map plays a role of paramount importance as to define the areas prone to detachment, transit and runout of slope instabilities.

3 Landslides

As a result of the complex sequence of volcanic and tectonic events, extensively described in Chap. Volcanic and Deformation History of the Campi Flegrei Volcanic Field, Italy, the Phlegraean hillslopes are either remnants of volcanic edifices or derive from the inner walls of the CFc. Consequently, along these slopes a peculiar geological setting can be recognised (Fig. 2), with a backbone prevailingly made up of weak, jointed tuffs and subordinately of lavas, surmounted by some tens of metres of loose pyroclastic deposits. The main geomorphological feature of the Phlegraean hills is their quite high "relief energy". In fact, despite their relatively moderate altitude (max. elevation: Camaldoli Hill, 458 m a.s.l.), local hills show high slope angles (>30°), which reach the highest values where cliff-forming tuffs and lavas crop out. In addition, the drainage network is markedly controlled by structural factors, where low-order straight channels clearly prevail, usually coinciding with morphostructural lineaments. Consequently, small-scale fans are present at the mouth of the main channels only, while more often the material displaced from hillsides tends to remain very close to the foothill, hence showing a moderate proneness to invasion.

The data so far available for the six Phlegraean towns are reported in Fig. 3, where the inventoried events refer to a timespan of slightly less than two thousand years. In fact, the oldest evidence related to mass movements can be found within the Ancient Centre of Naples, in the archaeological site found under the San Lorenzo church. Here, 7 m below the present-day ground surface, the city market, built in the first century BC, is partly buried under a chaotic deposit ascribed to a flood which occurred at the end of the fifth century CE (Touring Club Italiano 2001; Morra et al. 2010).

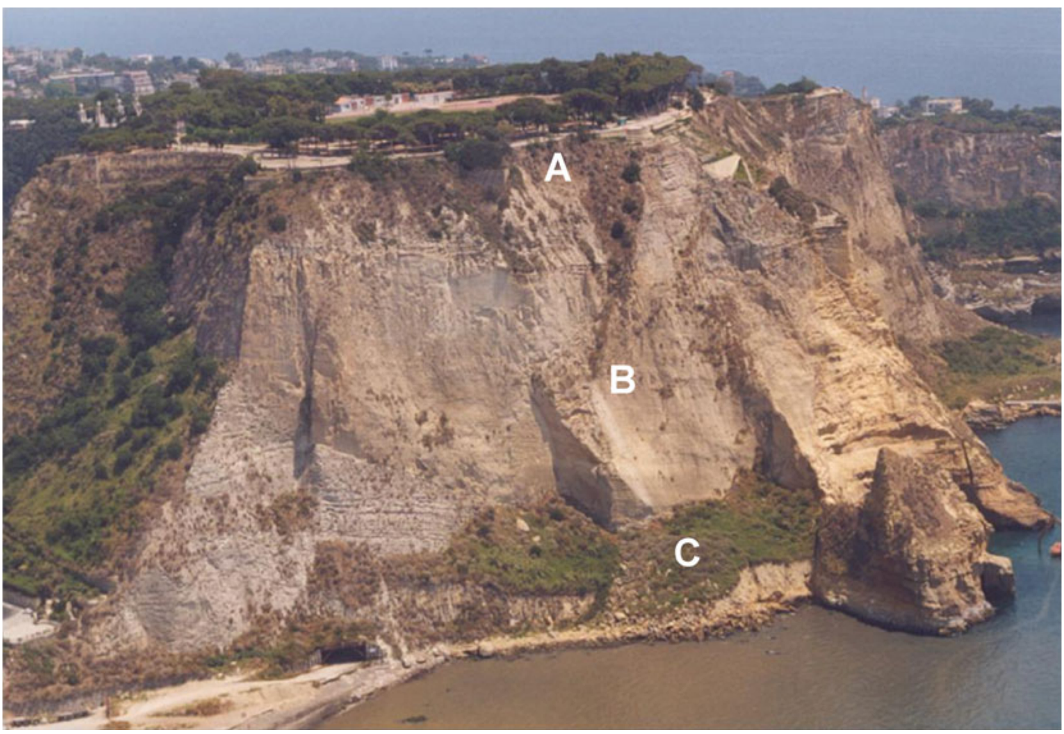

Fig. 2 Typical Phlegraean slope (Posillipo Cape, Naples). **A** Loose pyroclastic terrains, younger than 15 ka; **B** Neapolitan Yellow Tuff; **C** Landslide debris. Photo by the authors

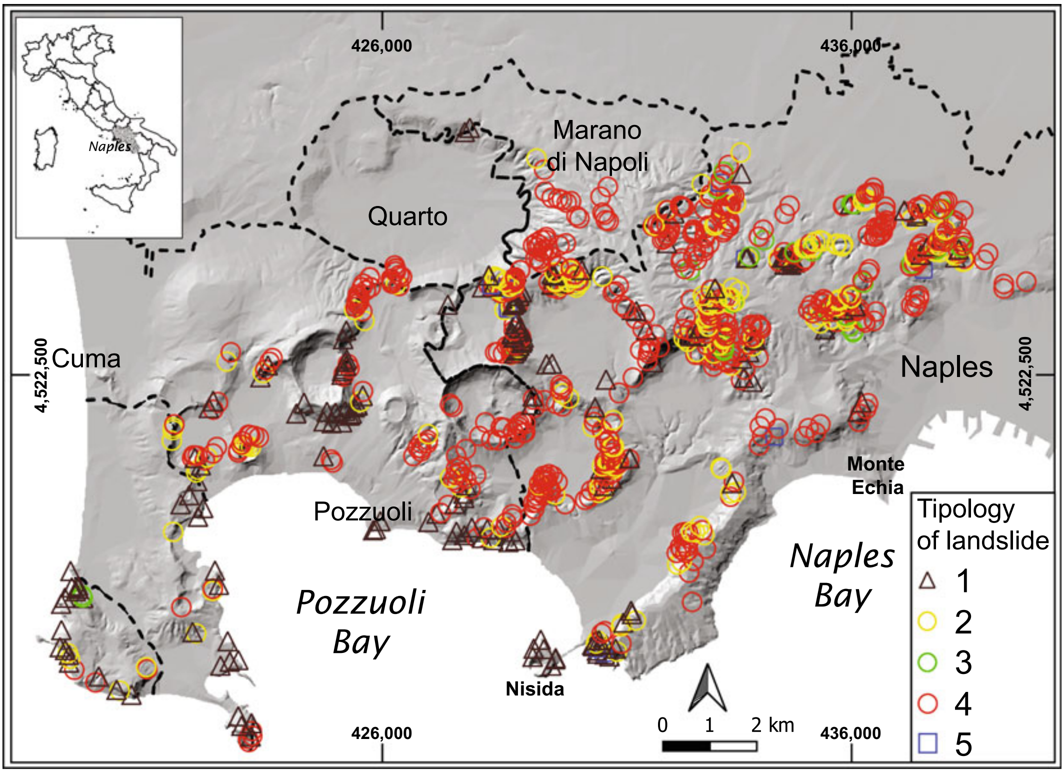

Fig. 3 Landslide-inventory map of the Campi Flegrei volcanic field. 1. Fall/topple; 2. Flow; 3. Slide; 4. Complex landslide; 5. Unclassified landslide. Author's unpublished data

The deadliest landslide among those known of the entire CFvf struck Naples on January 28, 1868 (Fig. 4). On that occasion 60 victims and tens of injuries were caused by a huge rockfall which detached from Monte Echia (Fig. 1), in the Chiaia borough, and reached the nearby Castel dell'Ovo (Calcaterra and de Luca Tupputi Schinosa 2006). After the event, a legal suit went on for about 40 years, and in 1908 the huge sum of 1,300,000 Italian lire (corresponding to a present-day value of about 5 million euro) was granted by the Italian government for the landslide repair project. Other relevant slope instabilities involved the urban area of Naples in the nineteenth century, such as a rockfall in NYT that took place on New Year's Eve of 1889 and disrupted an important road running along the coast of Posillipo (Gunther 1993) (Fig. 1). The occurrence of a reply in the same place on January 11, 1889, induced the authorities to remove some unstable blocks by bombarding them from the sea. The unusual intervention started on January 21 and ended on February 2, when 200 m^3 of NYT moved downslope, seriously damaging an edifice (Calcaterra et al. 2002).

The twentieth century CE started with a huge rainfall event, which, on October 24, 1910, affected vast portions of the Campania region, with the epicentral area located in the Amalfi coast, where 200 people lost their lives. However, Naples and the surrounding towns were also severely hit on that occasion, suffering serious material damage. Based on contemporary newspaper reports, about 150 mm of rainfall were discharged at Naples in about four hours.

Coming to more recent times, in the last decades of the past century some rainfall-induced episodes can be highlighted, among which those occurred in February 1986, January 1997, September 2001 and March 2005 are probably

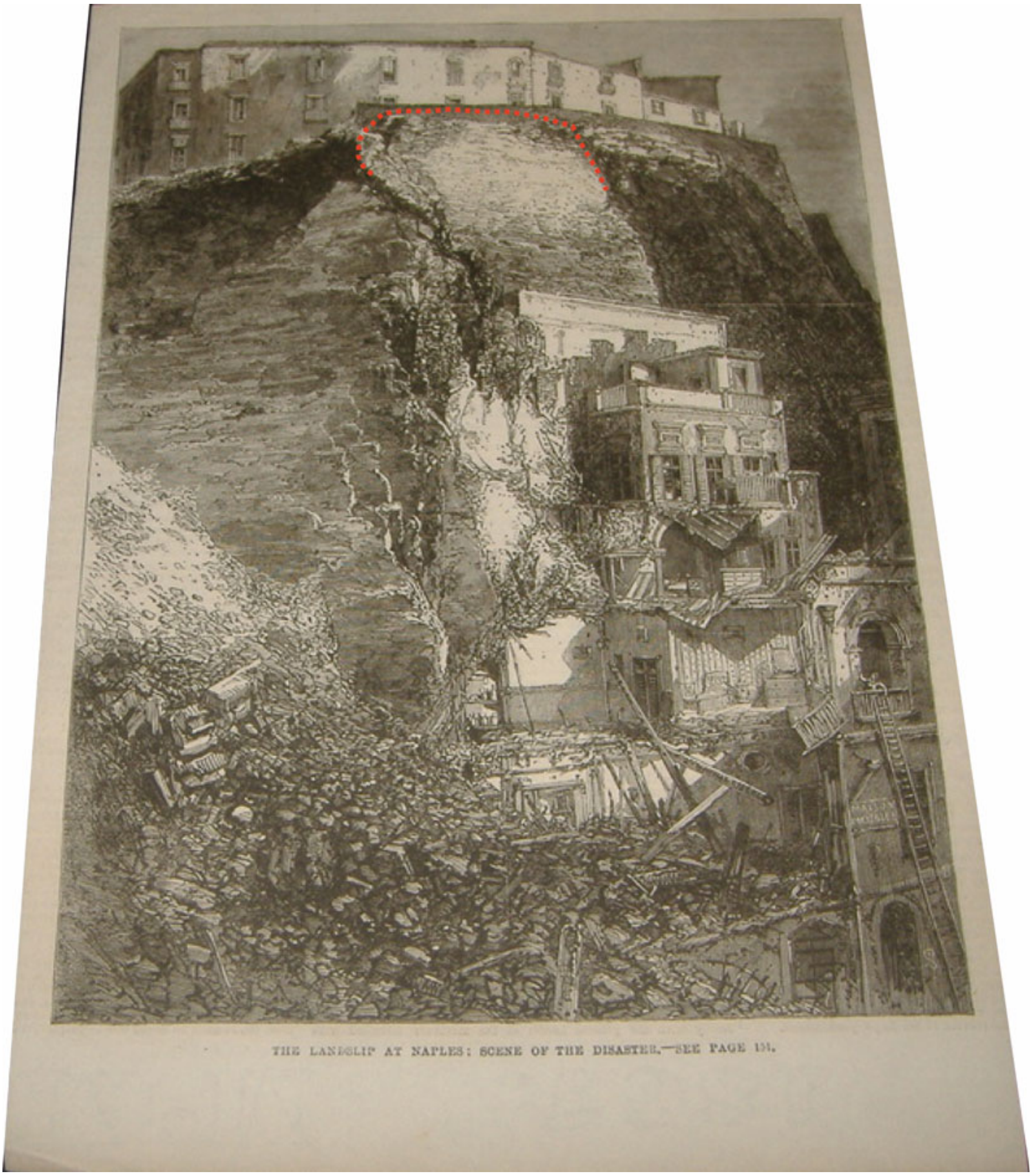

Fig. 4 The January 28, 1868 Monte Echia landslide. Red dotted line refers to the crown of the mass movement. Figure modified after Emporio Pittoresco (1868)

the most important in terms of effects. The 1986 event produced the worst effects in the western part of Naples (Fig. 5), as well as in the remaining towns of the Phlegraean continental area (Beneduce et al. 1988). Naples was again the focus of the event that occurred on January 10–11, 1997, when 110 mm of rainfall fell in 40 h (maximum hourly intensity: 10 mm) and, preceded by a long rainy period, triggered a huge cluster of landslides. Calcaterra and Guarino (1999a, b) described the basic features of that event, when some hundred shallow landslides (Fig. 5), mostly of the slide-flow type, involved essentially the loose pyroclastic rocks younger than 15 ka, causing severe damage to man-made structures. A large majority of such phenomena took place along the slopes of the western sectors of the city (Camaldoli Hill, Posillipo Hill, Agnano Plain) (Fig. 1).

Two more instability episodes, characterised by highly variable values of rainfall duration and intensity, affected the Phlegraean area in September 2001 (183.4 mm in 4 h) and March 2005 (130.2 mm in 27 h). In the first case, water-driven debris travelled for quite long distances along the Camaldoli hillslopes (Fig. 1), sometimes reaching the foothill inhabited areas. The 2005 event mainly involved the territory of Pozzuoli (Figs. 1 and 5). Here the worst single movement was a small-scale translational slide which invaded the track of a usually heavily trafficked motorway (Fig. 5): luckily, only material damage was caused.

By integrating all the available data coming from different sources, slightly less than 1,500 landslides have been inventoried in the six towns of the study area, among which Naples is by far the leading one, with about 75% of the total (Fig. 6). Analysing the same data in terms of areal density, the highest value pertains to Naples (9.4 events/km^2), followed by the smallest town, Monte di Procida, where 7.4 landslides per square kilometre have occurred; the mean value is 7.1. All these values are notably higher than the one of the Campania region (1.71), which in turn is similar to that (1.6) established by the Italian Institute for Environmental Protection and Research (Istituto Superiore per la Protezione e la Ricerca Ambientale) (2008) for the whole Italian territory.

Complex landslides, following the Varnes (1978) classification scheme, are the prevailing type (Fig. 6) with single contributing movements depending upon the lithological characteristics of the involved rocks: slides and flows dominate in the loose pyroclastic deposits, while falls and topples characterise the slopes along which tuffs and lavas crop out.

As evident from Fig. 7, all the Phlegraean landslides show a moderate mobility, expressed in terms of H/L ratio or "angle of reach" (i.e., the angle of the line connecting the highest point of the landslide crown scarp—H—to the distal margin of the displaced mass; Heim 1932). In fact, the travel distance of all the main Phlegraean landslide types (slides, falls/topples and complex movements) show a runout distance lower than 350 m, with a mean value of the angle of reach equal to 39°. If the various types of movements are individually considered, no striking difference can be highlighted (Fig. 7).

The moderate invasion potential that characterises the Phlegraean landslides can be conveniently compared with the slope instabilities affecting the pyroclastic cover of the nearby carbonate ridges. In this case, the H/L ratio reaches values as low as 10–15°, corresponding to the channelled slide-flows occurred during the 1998 Sarno catastrophic event, with a typical higher bound at 25–30° (Calcaterra et al. 2004b).

4 Landslide Hazard and Risk

The subject of landslide/flood defence and soil conservation was treated in Italy for the first time in 1989, when a law was promulgated, at the end of a long process that started after the flooding of Florence in 1966. The main innovations introduced by this law were: the change in the frame of reference, from administrative (region, province or municipality) to geographical (river basin); the establishment of the River Basin Authorities, governmental agencies (either national, inter-regional or regional) in charge of land planning and management; the need for the River Basin Master Plan, a comprehensive planning act, dealing with different territorial and environmental issues, such as landslides, floods, groundwater, coastal erosion. However, it was only after nine years that the law was fully implemented, when, following the aftermath of the Sarno tragedy (160 people killed by flow-like movements in Sarno and four more Campanian towns—May 1998) a decree was issued (D.P.C.M. 29 September 1998). This decree, among other topics, defined the landslide and flood risk grades, from R4 (very high) to R1 (moderate), to be included in the Master Plans on behalf of the River Basin Authorities.

Fig. 5 Recent slope instabilities of the Neapolitan-Phlegraean area. **a** Post-fire shallow slides along the southern slope of the Camaldoli Hill (Naples, summer 1996); **b** Typical small-scale slide along the inner slope of the Agnano Plain (Naples, January 1997); **c** Cluster of slides at the border between Naples and Quarto (January 1997); **d** Translational slide that invaded the Naples bypass (Tangenziale) (Pozzuoli, March 4, 2005); **e** different generations of translational slides along the western slope of Monte Spina (Agnano Plain, Naples): 1. February 1986, 2. September 2002, 3. January 2003; **f** Slide at Cigliano (Pozzuoli, March 4, 2005); **g** Fall along the southern slope of the Camaldoli Hill (Naples, 2005—photo courtesy by A. Santo); **h** Column-like mass of Whitish Tuffs (see Chap. Volcanic and Deformation History of the Campi Flegrei Volcanic Field, Italy) prone to topple (Camaldoli Hill, Naples). For location of cited localities, see Fig. 1. Photos by the authors

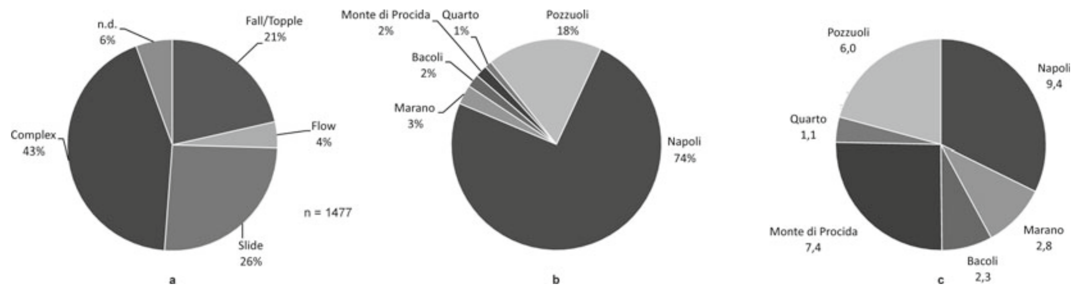

Fig. 6 Statistical features of the Phlegraean landslides. **a** Type of events; **b** Percentage of total events in each town; **c** Density of events (number/km^2) in each town. Author's unpublished data

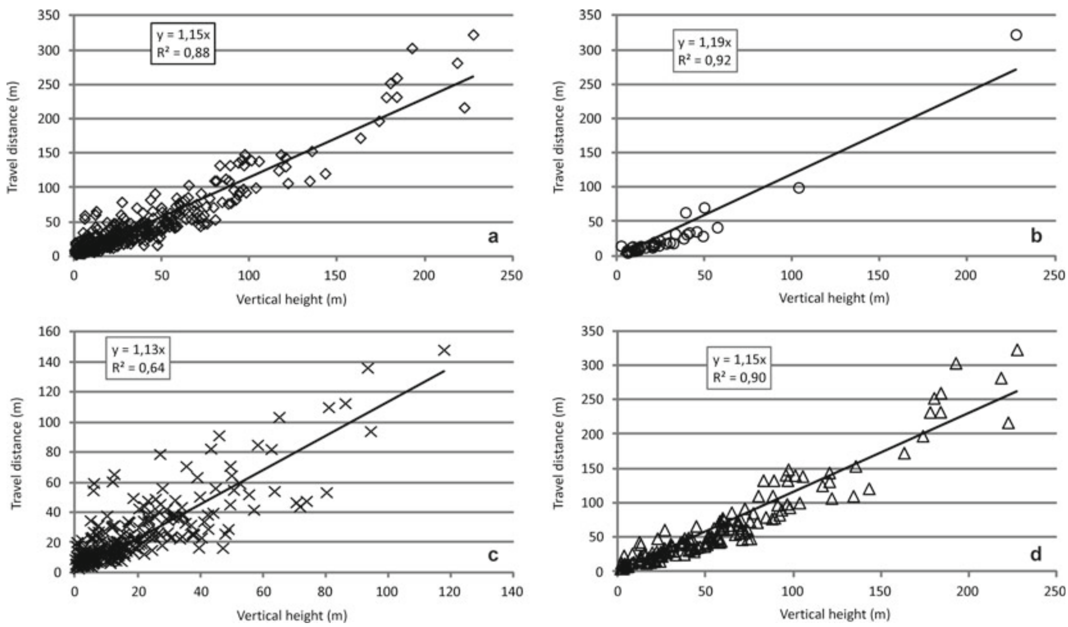

Fig. 7 Relationships between vertical height (H) and travel distance (L) for the Phlegraean landslides. **a** All types (n = 453); **b** Falls/topples (n = 45); **c** Slides (n = 262); **d** Complex (n = 146). Author's unpublished data

The Phlegraean towns fall under the jurisdiction of the Basin Authority of the North-western Campania Region that issued its Hydrogeomorphological Setting Plan in 2002 and revised it in 2010. Both versions of the Plan were released at a 1:5,000 scale. The procedure adopted to obtain the final landslide risk map has been extensively described by Calcaterra et al. (2003a) and Di Martire et al. (2012) and critically reviewed by Sorriso Valvo (2005).

Landslide risk, subdivided in the four official levels, affects more than 15% (31.9 km^2) of the whole territory of the six Phlegraean towns (Fig. 8). The figure is coherent with that referred to all the towns under the control of the Basin Authority of the North-western Campania Region (16%). However, the distribution of the at-risk areas among the six towns is uneven: Monte di Procida is, in fact, the town most exposed to landslides, with 31.7% of its territory, while at Quarto the percentage drops down to 5% (Figs. 1 and 8). A very high percentage (72%) of all the at-risk areas falls in the two highest risk grades, where loss of human lives (R4) or serious threat to public safety (R3) is expected.

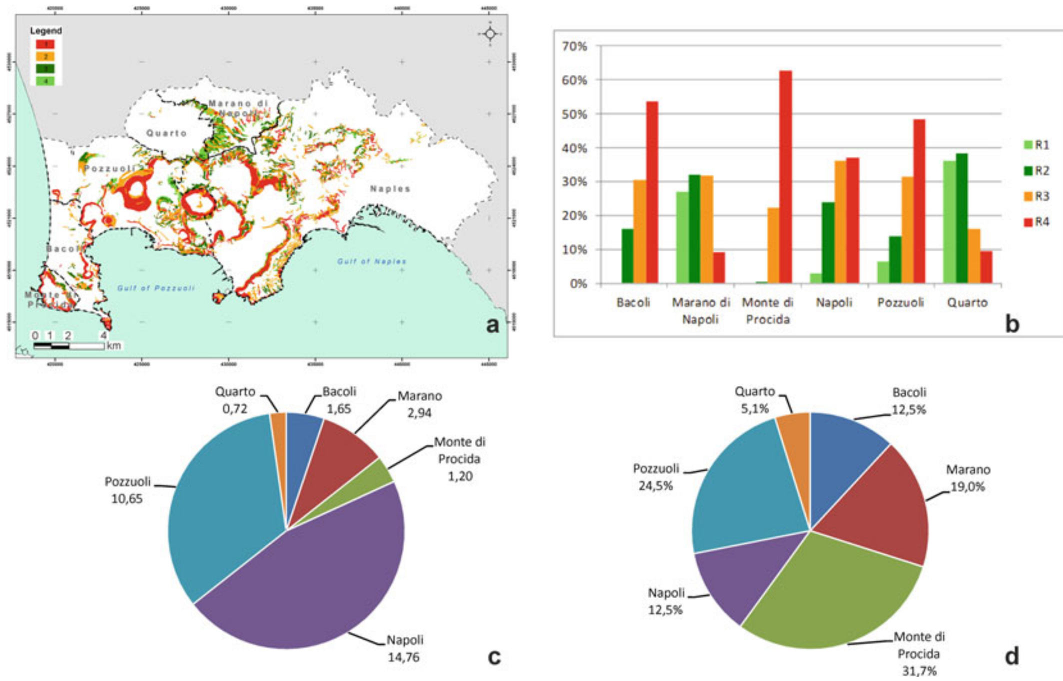

Fig. 8 Summary of the landslide risk conditions for the Phlegraean towns (Author's unpublished data). **a** Landslide risk map (modified after Basin Authority of the North-western Campania Region 2010): 1. Very high risk; 2. High risk; 3. Medium risk; 4. Moderate risk; **b** Distribution of landslide risk levels within each town; **c** Total area exposed to landslide risk within each town; **d** Percentage of areas exposed to landslide hazard within each town

5 Considerations on Landslide Hazard Mitigation and Risk Reduction

According to the results of the previously presented detailed studies performed over the last 20 years, landslides have to be considered one of the sources of natural hazards for the entire CFvf. Their typologies, geological and geomorphological features, triggering conditions and invasion potential are among the key-aspects, which have been so far treated in depth, thus allowing a reasonably good comprehension of the propensity to slope instabilities in the whole area.

With respect to the two main rock types erupted by the CFvf, post-NYT loose pyroclastic terrains and lithified tuffs, some basic similarities and differences in the Phlegraean landslides can be determined. Both rock types are in fact affected by small-scale phenomena, characterised by a relatively low mobility. On the contrary, the geological and geomechanical features of each of them favour different types of landslides. Loose pyroclastic rocks mostly generate open-slope slides that can evolve into debris flows; on the contrary, tuffs, due to their both typical columnar jointing and exposure in sub-vertical natural cliffs, cut slopes or quarry walls, induce falls and topples.

The Phlegraean landslides have been triggered by both natural physical processes and man-related activities. In fact, if rainfall represents the main triggering cause, anthropogenic actions significantly contributed to landslides generation (Calcaterra et al. 2002; Di Martire et al. 2012). In the past, especially at the turn of the twentieth century, quarrying activity and excavations played a significant role in causing landslides. More recently, the progressive abandonment of agricultural practices along with extensive urbanisation of the slopes (often illegal) and wildfires have assumed a greater relevance (Calcaterra et al. 2007b; Di Martire et al. 2012).

Despite their moderate mobility, landslides in the study area represent a serious threat for the local population due to the wild expansion of the urban areas (Chap. The Urban Development of Campi Flegrei, Italy). Especially after World War II, urbanisation has progressively expanded toward foothill zones, hence occupying relatively unsafe territories and determining a serious exposure of people and infrastructures to slope-related instabilities. Nowadays, some of the foothill boroughs show population densities among the highest in the western countries (e.g., Soccavo with 9,300 inhabitants/km^2) (Municipal Government of the City of Naples 2007).

As a result, landslide risk conditions of the entire CFvf are definitely troublesome, with a relevant percentage of territory exposed to a high to very high risk, which, following the Italian legislation, imply the possibility of loss of human life and irreparable damage to property. Therefore, the issue of landslide risk mitigation in the Phlegraean towns is of paramount importance, as a key-aspect in the attempt to improve life quality and territorial safety.

In the last 15 years, several remedial measures have been designed and partly implemented. To this respect, the turning point was represented, at least for the city of Naples, by the institution in 1997 of a special governmental agency (in Italian, *Commissariato Straordinario di Governo*) in charge of planning and managing structural and non-structural measures against landslides and floods. This agency benefited for over 10 years from extraordinary funds granted by the national government. In these years, some types of remedial measures have been more frequently adopted in the CFvf, inspired to both active and passive principles. In the first case, stabilisation works have been aimed at preventing future triggering of mass movements, usually leading to an increase of the safety factor in the slope sectors susceptible to detachment. Passive countermeasures have reduced the risk, protecting man-made works from impacts, for example controlling the distance and direction of landslide travel. Falls and topples affecting the weak tuffs, such as the NYT, have been usually stabilised through rock removal or scaling, bolts, wire mesh or woven wire-rope nets and, more rarely, passive solutions such as ditches, barriers or fences (Fig. 9). Fast-moving slide-flows involving the post-NYT loose pyroclastic deposits have been prevailingly mitigated by means of passive works such as check dams and retention basins, located in the lower reaches of the slope channels and at the mouths. However, the efficiency of the latter works is seriously hindered by a chronic lack of maintenance, basically represented by a periodic removal of any debris and silt build-up (Fig. 9). In the same years, a considerable effort has been put into an attempt to reduce the environmental impact of the remedial measures. To this aim, biotechnical slope stabilisation works have been adopted, such as vegetated timber walls, geogrids, contour wattling, brush layering, biotextile revetments, live wooden crib-walls (Fig. 9).

6 Conclusive Remarks

Naples and the Phlegraean towns are an iconic example of a densely populated urban territory highly vulnerable to recurrent landslides. Such recurrent threat has been, over the time, triggered by both natural and human-induced causal factors. In fact, if in recent decades all the main geomorphological crises (e.g., 1986, 1997, 2001) have been caused by intense and/or prolonged rainfall events, at the turn between nineteenth and twentieth century landslides were of a prevailing anthropogenic nature, due to a strong urban expansion which, at that time, involved some of the urban hillsides (e.g., Posillipo; Fig. 1).

However, even though 150 years of documented events clearly testify of a recurring hazard, it is not possible yet to assign a given “return period” to Phlegraean landslides, also considering the variety of instabilities (falls, topples, slides, complex) which affect both soils and rocks cropping out in the Phlegraean area. Therefore, taking into account the different predisposing factors recognised in the area, wide portions of its territory have been classified as

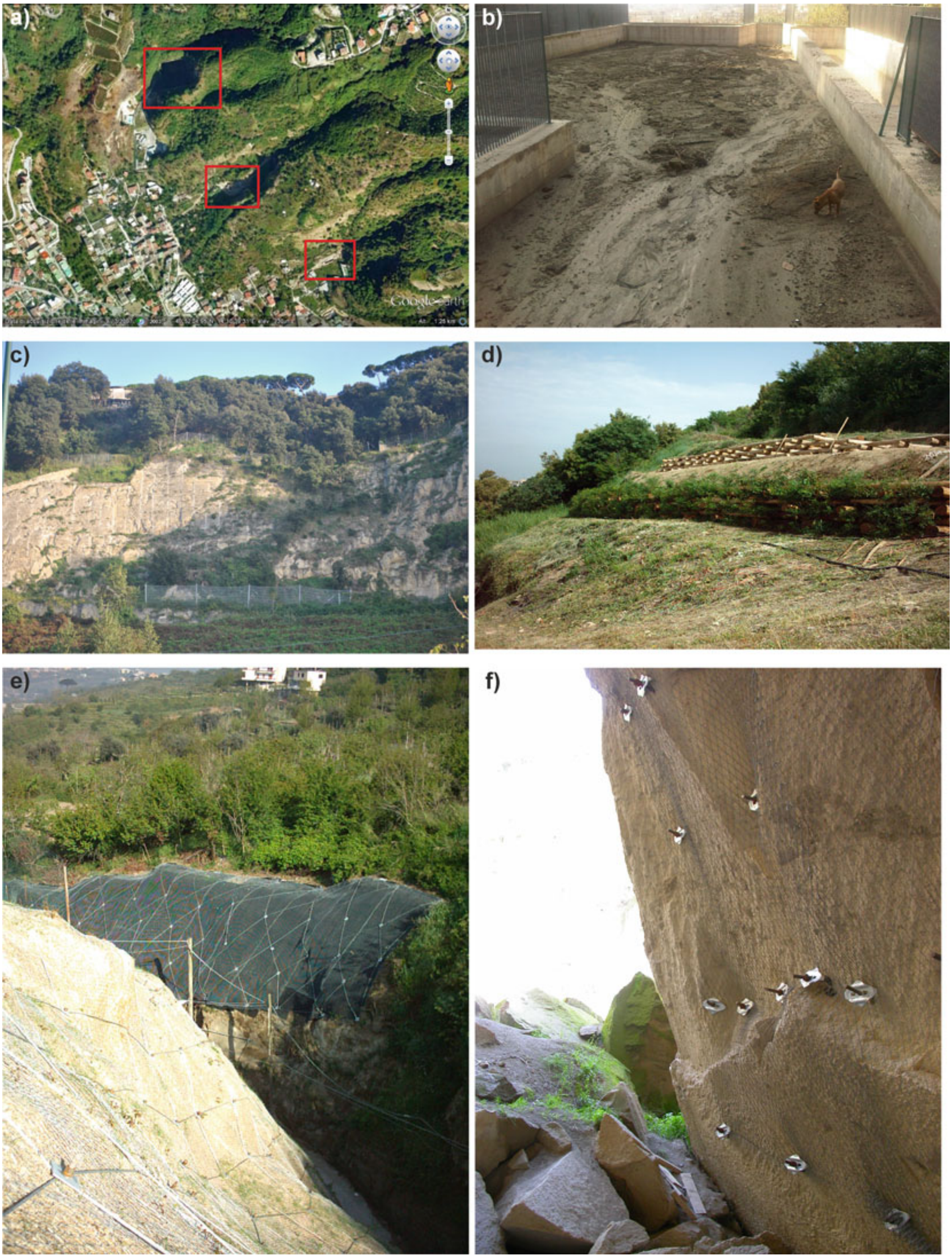

Fig. 9 Examples of structural remedial measures adopted to mitigate landslide risk in the Campi Flegrei volcanic field. **a** Camaldoli Hill (Naples): in the insets, some retention basins; **b** One of the Camaldoli retention basins completely filled with debris; **c** Posillipo Hill (Naples): integrated solution, through joint sealing and flexible fences; **d** Marano di Napoli: live double-layer wooden crib-wall. **e** Marano di Napoli: geogrid revetment and hexagonal double-torsion net coupled with hydroseeding; **f** Naples: rock nails and wire-mesh net. For location of cited localities, see Fig. 1. Photos by the authors

exposed to high or very high landslide risk (11%), corresponding to about 23 km^2.

From this perspective, the Phlegraean area is a sort of "litmus test", which well shows how critical is the Italian situation in terms of resources needed to mitigate landslide risk. In fact, a quite recent survey has shown that more than eleven thousand priority interventions are needed to significantly reduce the landslide and flooding risk over the Italian territory; the related costs have been evaluated at about forty billion Euros (Giannella and Guida 2010). On the other hand, from 1991 to 2008 the Italian government has invested about seven billion euros of ordinary funds for the mitigation of landslide and flooding risk. This implies that, maintaining the same average annual expenditure values, 100 years would be necessary to reach a reasonable level of structural protection against landslides and floods.

It is therefore evident, that, due to the chronic scarcity of resources allocated for the implementation of structural measures against geohazards, a fundamental commitment is to improve the Nations' understanding of where and how they are vulnerable to natural hazards and how to effectively respond so that recovery is rapid when catastrophes occur. To this aim, the World Conference on Disaster Reduction held in 2005 at Kobe, Japan, launched a worldwide campaign centred on societal resilience to natural hazards, a concept that implies exposure, sensitivity, and adaptive capacity of human-environmental systems. Since 2005, Italy participates to the Hyogo Framework for Action; some of the largest Italian cities, among which there is Naples, have joined the campaign of resilient cities, which aims to strengthen the capacity of disaster response at the local level. However, it must be stressed that no investments of specific resources to implement prevention campaigns or risk management have been made up to now.

Nowadays 50% of the world population is living in urban areas, a figure which is expected to double in the next 30 years. Recent catastrophic events in Italy and elsewhere have clearly demonstrated that the severity of damage largely depends on how much both high value assets and critical urban infrastructure are affected, either directly or indirectly. It is therefore hoped, especially in this persistent period of political and economic crisis, that governments could understand the importance of investing in non-structural preventive measures devoted to reducing natural hazards. Such an option, among other benefits, allows remarkable economic savings, if compared to the huge amounts of money usually needed in the post-emergency costs, and, above all, promotes a responsible behaviour in the public.

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